ELECTRONICS TARGETS

JAPANESE EXPERIMENTAL RADAR

U.S. NAVAL TECHNICAL MISSION TO JAPAN

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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
SAN FRANCISCO, CALIFORNIA

31 December 1945

RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Experimental Radar.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Target E-12 of Fascicle E-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lieut. W.G. Lamb, USNR, and Lieut. E.E. Schwaln, USNR, assisted by Lt.(jg) S.H. Kadish, USNR, as interpreter and translator.

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JAPANESE EXPERIMENTAL RADAR

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE E-1, TARGET E-12

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ELECTRONICS TARGETS

JAPANESE EXPERIMENTAL RADAR

At the end of the war Japanese experimental radar and developmental radar could be divided into four general groups.

1. 60cm conical scan
   S8A (land based)
   Mark 6, Model 1 (S8B) (land based)
   Type 3, Mark 2, Model 3 (S8) (shipborne,

2. 10cm surface search and fire control
   Mark 3, Model 2 (shipboard and land based)
   Mark 3, Model 1 (shipboard and land based)

3. Improvement of meter wave radar
   Mark 6, Model 3 (land based)
   Type 2, Mark 2 Model 1, Modification 5 (shipborne)
   Model K Simplified Radar (land based)

4. Direction of friendly craft (used with M-13 IFF)
   Mark 6, Model 2 (land based)
   TH (land based)

The general trend was to shorter pulse lengths, narrower widths, and shorter wave lengths, except for long range AA early warning. Broad band antennas and simplified circuits were under development for meter wave radars. Extensive tests were being conducted on the use of the M-13, IFF, in conjunction with suitable land based radar for direction of friendly craft. The Mark 6, Model 1 radar, a narrow beam conical scan, 60cm equipment, was originally designed for direction of friendly aircraft.

No unusual techniques or outstanding developments were found in any of the experimental radars.

Experimental airborne radar is discussed in NavTechJap Report, "Japanese Airborne Radar", Index No. E-02.

TABLE OF CONTENTS

LIST OF ENCLOSURES

REFERENCES

Location of Target:

Second Naval Technical Institute, KANAZAWA

Second Naval Technical Institute, Meguro Branch, TOKYO

Naval Fighter Direction Station, CHIGASAKI

Japanese Personnel Interviewed:

As listed in Enclosure (A)

INTRODUCTION

This report covers Japanese experimental shipborne and land based radar. Experimental aircraft radar is treated in NavTechJap Report, "Japanese Airborne Radar", Index No. E-02.

The information and conclusions are based upon interrogation of Japanese naval and technical personnel and inspection of equipment and experimental facilities.

THE REPORT

A. GENERAL DISCUSSION

Japanese experimental radar demonstrated the trend in design and operation at the close of the war. The value of the shorter wave lengths for AA fire control and micro waves for surface search and fire control were well appreciated. Higher accuracy was being obtained by narrower beam widths and shorter pulse lengths, although the low power output of magnetrons limited pulse lengths of 10cm equipments to about ten microseconds. Considerable work was being done on improvement of the antennas and simplification of the circuits of the meter wave, early warning sets. Experiments and developments were being carried out in direction of planes and ships from a central fighter direction station.

B. 60cm CONICAL SCAN RADARS

There were three conical scan radars in the 60cm band under development.

Type 3, Mark 2, Model 3 (S8)

Wave length	58cm
Peak power	5 kw
Pulse length	2.5 micro seconds
Pulse rate	3750 cps
Antenna	Two 1.7 meter parabolas

This equipment was installed on shipboard for surface fire control; separate antennas were used for transmitting and receiving. Development was completed in March 1944. Indicators were of the conventional type: a scan for search, expanded sinusoidal for range, and "pip" matching for bearing.

S8A

Use	Land based AA fire control
Wave length	60cm
Peak power	6 kw
Pulse length	2.5 micro seconds
Pulse rate	3750 cps
Antenna	2.9 meter parabola

Mark 6, Model 1 (S8B)

Use	Land based fighter direction
Wave Length	60cm
Peak power	10 kw
Pulse length	2.5 micro seconds
Pulse rate	1000 cps
Antenna	7 meter parabola

The S8A was in development from September 1944 to December 1944 and was followed by the S8B which was started in December 1944 and completed in April 1945. These two radars were equipped with gas discharge tube duplexers and single antennas for transmitting and receiving. The S8B was originally designed for fighter direction but, after the longer wave AA fire control radars had been jammed, plans were maie for its use as a fire control radar. The oscillators for the S8A and S8B were enclosed in a cast shield which formed the tuned circuit for the transmitter. Pip-matching indicators were used for bearing and elevation; an expanded sinusoidal sweep gave accurate range data, and an "A" sweep was used for search. All three of these radars show definite evidence of German influence.

C. 10cm FIRE CONTROL AND SEARCH

The 10cm fire control development was concerned primarily with antenna and indicator improvement over the basic Mark 2, Model 2 design. Characteristics are as follows:

Mark 3, Model 1 (220)

Use	Shipborne and land based Surface fire control
Wave length	10cm
Peak power	2 kw
Pulse length	10 micro seconds
Pulse rate	2500 cps
Antenna	parabolic

Mark 3, Model 2 (105S2)

Use	Shipborne and land based Surface fire control
Wave length	10cm
Peak power	2 kw
Pulse length	10 micro seconds
Pulse rate	2500 cps
Antenna	3 horns: 1 transmitting, 2 receiving

The 220 radar employed a parabola with an oscillating feed producing a 5°, 10 cycle sinusoidal scan. A selected signal was applied to the vertical deflection plates of the bearing CRT and a sinusoidal bearing sweep was applied to the horizontal. Bearing accuracies of plus or minus three quarters of a degree were claimed. The 105S2 depended on horizontal lobing for bearing accuracy. This lobing was accomplished by switching alternately from one receiving horn to the other. Indications were: pip matching for bearing, "A" scan for search, and expanded sinusoidal sweep for range. The 105S2 was also used, without lobing, as a surface search radar for harbor and shore protection.

D. IMPROVEMENT OF METER WAVE EQUIPMENT

The Mark 6, Model 3 (land based) and the Type 2, Mark 2, Model 1, Modification 5, were equipped with broad band antennas and duplexing systems. It was stated that the stability of these equipments was greatly improved by lobing only while in the receiving condition. The Mark K Simplified Radar is a light weight land-based radar whose circuits were designed so that no high voltage rectifiers were required. This was accomplished by synchronizing the whole system with the power supply frequency.

E. DIRECTION OF FRIENDLY CRAFT

Mark 6, Model 2 (62)

Wave length	2 meters
Peak power	10 kw
Pulse length	2.5 micro seconds
Pulse rate	500 cps

TH Radar

Wave length	1.5 meters
Peak power	13 kw
Pulse length	6 micro seconds
Pulse rate	1000 cps

These two radars are very similar, being used in conjunction with the M-13

IFF or the M-13 IFF modified. In this system the radar interrogated the M-13 on a plane or surface craft and received an answer back on a slightly different frequency. A broad band antenna was used. The TH radar is identical with the L3 searchlight control radar except for the antenna and indicators.

ENCLOSURE (A)

JAPANESE PERSONNEL INTERVIEWED

* * *

LEGEND

I.U. - Imperial University
E.E.S. - Electric Engineering Section
C.E.S. - Chemical Engineering Section
S.S. - Science Section

* * *

Name	School and Year of Graduation	Specialities
Vice Adm. T. NAWA	Tokyo I.U. (E.E.S.) 1917 Studied Chemistry in Tokyo I.U. (S.S.) 1919-1922	Chief of Radar and Communication Department.
Capt. H. TAKAHARA	Naval Academy 1919 Tohoku I.U. (E.E.S.)1932	Head of Fourth Section (radar intercepter, radio beacons and directional findings).
Capt. and Dr. Y. ITO	Tokyo I.U. (E.E.S.) 1924 Technische Hochschule Dresden, Germany 1927	Head of First & Second Section (fundamental researches).
Capt.(Tech.) Y. YAJIMA	Tohoku I.U.(E.E.S.) 1924	Secretary to T. NAWA, Head of Production Section.
Capt. I. ARISAKA	Naval Academy 1923 Tohoku I.U.(E.E.S.) 1934	Head of Third Section of Communication Dept. (radio equipment).
Capt. K. NAGAI	Naval Academy 1924	Member of Administration Department.
Lt.Comdr.(Tech.) T. HYODO	Tokyo I.U.(C.E.S.) 1936	Researcher on materials and components for high frequency use
Lt.Comdr.(Tech.) S. KATSURAI	Tokyo I.U.(E.E.S.) 1936	Researcher on land and airborne radars (Type 51, 61, 63).
Lt.Comdr.(Tech.) S. MORI	Tokyo I.U.(E.E.S.) 1937	Researcher on shipborne radar (cm wave, i.e. 22)
Lt.Comdr.(Tech.) N. TSUJITA	Kyoto I.U.(S.S.Physics) 1936	Researcher on airborne radar (meter wave, i.e. FE-3, FH-3, FE-4, E-6).
Lt.Comdr. K. KAMIYA	Tohoku I.U.(E.E.S.) 1936	Researcher on components and tubes for high frequency.

ENCLOSURE (A), continued

Name	School and Year of Graduation	Specialities
Lt.Comdr.(Tech.) O. OKAMURA	Tokyo I.U.(E.E.S.) 1940	Researcher on tube for cm wave.
Lt.Comdr. S. MATSUI	Naval Academy 1934 Osaka I.U.(S.S.Physics) 1942	Head of research in YOKOSUKA Branch (research on installation of shipborne and land based radio and radar)
Lt.Comdr.(Tech.) W. SUGIYAMA	Waseda University(E.E.S.) 1940	Researcher on high cable in YOKOSUKA Branch.
Lt.(Tech.) K. OGATA	Tohoku I.U.(E.E.S.) 1941	Researcher on land based radar (cm wave, i.e. 61).
Lt.(Tech.) S. KAWAZU	Tokyo I.U.(E.E.S.) 1941	Researcher on land based radar (meter wave i.e. 14, 62).
Lt.(Tech.) S. YAMANE	Kyoto I.U.(E.E.S.) 1942	Researcher on airborne radar, countermeasures.
Lt. K. MORI	Naval Academy 1940	Teacher in Radar Training School.
Dr. K. TAKAYANAGI	Kuramae Tech. College 1921	Consultant to T. NAWA, Head of Third Section (Radar).
Eng. N. SHINKAWA	Waseda University(E.E.S.) 1933	Researcher on radar (meter wave, i.e. L-2, L-3, S-3, S-24, N-6, M-13).
Eng. M. MACHIYAMA	Tokyo I.U.(S.S.Physics) 1933	Researcher on high freq. circuits for cm wave.
Eng. S. SUZUKI	Tokyo Physical School 1929	Researcher on airborne (meter wave N-6) radar
Eng. K. UEMINAMI	Washington University U.S.A. 1934	Researcher on airborne radar intercepter and airborne direction finder.
Mr. R. KIMURA	Waseda University 1930	Consultant to H. TAKAHARA (researcher on radio frequency instruments in Electro Technical Laboratory of Japanese Government).
Mr. S. NISHIYAMA	Uta University 1932	Interpreter.

ENCLOSURE (B)

SUMMARY OF ACTIVITIES OF THE RADAR AND COMMUNICATION DEPARTMENTS THE SECOND NAVAL TECHNICAL INSTITUTE

September 1945

(Translation)

SECTION 1 OF THE RADAR DEPARTMENT

Group 1: Researches on Magnetron Tubes

In 1944, the extreme importance of the application of centimeter waves to radars led us to establish a laboratory at SHIMADAMACHI, Shizuoka-ken, to study the fundamental problems on magnetron tubes. The study has advanced favorably, and made clear the theoretical mechanism of magnetron oscillation which enabled us to make various types of magnetron oscillators. However, the researches could not be fully completed in time for this war.

Group 2: Researches on Apparatus "A"

As one application of centimeter waves, a radio controlled method of igniting detonator was under study. Setting a suitable antenna and a detonator in an anti-aircraft shell, we could explode a shell by the antenna current induced by a sharp directive centimeter wave radiated from the ground.

In order to cause explosions directly by the antenna current, the transmitter power must be extremely large. The efforts were concentrated on producing a powerful oscillator. An oscillator of 50 kilowatt input of 10 to 20 centimeter wave length was just completed for test. This had led us to the stage of carrying out actual tests with a parabolic reflector of 10 meter diameter, which should give a sharp beam wave.

SECTION 2 OF THE RADAR DEPARTMENT

Group 1: Research on Electron Tubes

This group undertakes the researches on electronic tubes commonly used for radar and communication apparatuses. On April 14th, the laboratories of the Meguro Branch were burned and the work was continued in the laboratories of the manufacturers and at Negishi Experiment Station.

(1) Checking receiving tubes: Commonly used receiving tubes such as FM 2A05, "sora" RE-3, etc., were constantly checked as to quality.

(2) Checking transmitter tubes: Commonly used transmitter tubes such as T-304, T-304A, T-321, etc., were constantly checked as to quality.

(3) Research on tubes of new design: Researches were carried out to develop the following types of tubes: large output oscillator tubes for decimeter waves, secondary emission amplifier tubes, velocity modulated tubes, and high frequency amplifier tubes for decimeter waves.

Group 2: Research on Super UHF Equipments

In the laboratory of the Nippon Musen Company, the following problems were studied: design of a circuit for 10 centimeter radar capable of transmitting as well as receiving, crystal detector for super UHF purpose, discharge tube for modulation use and its circuit, and radiating system for centimeter wave radar.

ENCLOSURE (B), continued

Group 3: Research on Parts and Materials

This group was assigned the problems of: standardizing of parts and materials, development of testing technique for parts and materials, and development and testing of high frequency materials.

Group 4: Research on Antenna System (Cooperated with the Yokosuka Air Corps)

Study was made to develop a high efficiency antenna for airborne radar and communication equipments.

SECTION 3 OF THE RADAR DEPARTMENT

Group 1: Research on Radar for Night Fighter Use

The 60 centimeter radar designed for night fighters was not used in the war because of its inadequate effective range. Therefore, fundamental research to increase the power output of the transmitter and the gain of the receiver was undertaken. Flight test on night torpedo bomber was underway.

Group 2:

(1) Research on radar for small patrol planes, Type N-6: Several sets of 1.2 meter radars for small patrol planes were made for tests. Flight tests showed them to be inadequate in range. Therefore, researches for improving Type N-6 Radar were started. The problems for improvement were: to adopt the anode modulation system, to increase the high altitude characteristics of the transmitter, to utilize the cavity resonator in the high frequency part of the receiver to increase the sensitivity, and to make the width of the impulse wave form narrower to improve the accuracy of measuring the distance and to increase the discriminating ability of targets. When air raids destroyed the Nippon Musen factory at HACHIOJI City, all of the sets were lost.

(2) IFF Types M-13 and M-13 Improved: Research was completed for airborne equipment to transmit a special signal to identify enemy from friend and which coordinates with Type 13 and Type 11-K warning radar used in greatest number by the Navy. Although its performance was not fully satisfactory, the apparatus was in production and was being put into service.

(3) Radar to guide boats, Type TH: The set was intended to guide friendly boats by locating them with the aid of a receiver and a transmitter placedon board. The search light control radar Type L-3 was used for the land equipment, while radar Type M-13 was used on board. The experiment was discontinued when tests showed unacceptably short range.

Group 3:

(1) Research on radar to guide fighters (HAMA-62) (land based): Although warning radar Type 13 (wave length 2m) has already been installed as land based or airborne equipments, its effective range and accuracy was wanting. Therefore, it could not be used to guide our interceptor fighter planes. The Type 62-B has an improved antenna system, and uses the indicator of the Type 11 radar which improved the ability to locate enemy planes over the interior of the country. The trial test was a success. The set may be seen at CHIGASAKI but production design could not be completed before the end of the war.

ENCLOSURE (B). continued

(2) Research on radar to guide fighters, with altitude indicator (HAMA-61) (land based): This is a radar for measuring enemy's position over water. Actual sets were in production but could not be completed due to repeated air raids. The test set is at CHIGASAKI, but it also was damaged by air raids.

(3) Research on Radar (Rotterdam Type) for large plane use (KASUMI-51);

This radar was designed to get panoramic scanning from airplanes, and was developed from the centimeter radar Type 220. The trial set was tested at MISAWA, and the result was not satisfactory.

Group 4: Research on "Centimeter Wave" Radar

Types 105-S2 and 220 radars are for naval ships, and were designed to detect and locate ships. We attempted to improve the Type 2-2 and the Type 105-S2 radar which has three electromagnetic horns, one for transmitting and two for receiving. The equipment is intended for land bases as well as for larger ship installations. The directional indication is obtained by the comparison method. The Type 220 radar has a parabolic reflector (1.7 meters in diameter) and measures the direction by the maximum method. It is intended for medium and large ship use. Tests showed the following results:

Battleship to Battleship

Type	Range (km)	ΔR (meters)	$\Delta\theta$ (degrees)	Notes
105-S2	35	100	0.5	Continuous tracking Point
220	40	100	0.6	by point measurement.

ΔR is the error of range in meters.
$\Delta\theta$ is the error of the direction in degrees.

However, the radars were not installed because towards the end of the war we had very few large ships. On Type 220 we worked to obtain "direct indicating maximum method" with which we could track continuously, but the experiment was not completed.

Group 5:

(1) Research on radar for patrol planes (H-6): This is the most frequently used radar for patrol planes (wave length 2 meters), and is installed aboard large and medium size planes. The power source for this radar was being redesigned from 12 volts to 24 volts.

(2) Research on radar for small planes (FK-3): This radar was designed for 2 or 3 seater planes. The weight and size are much smaller than H-6 Type, and the performance is about 80% of that of the Type H-6. The trial set was completed in April of this year, and was in production and going into service.

(3) Research on radar for large plane use (FK-4): Researches on improving the Type H-6 radar were made to increase the ranges by 1.5 to 2 times that of the H-6 Type radar. The transmitter power was increased and the modulator system improved. The test was completed by the end of July, and its performance proved to be adequate. However, they were not put into service before the end of the war.

ENCLOSURE (B), continued

Group 6: Research on Antennas

(1) Research on radar antenna for patrol planes (Mark 5 antenna): This antenna consists of three Yagi antennas, one front and two sides, and was used on Type H-6 and Type FK-3 radars. The same antenna is used for both radars and was designed so that no frequency change might occur in switching over.

(2) Research on within-fuselage antenna: This antenna is designed to be installed aboard high speed planes. The antenna is installed within the fuselage on both sides. By switching over we could measure the direction of the target by the comparison method. When this antenna was used with the H-6 Type radar, the performance was about 80% of that of the Mark 5. This antenna was just being placed in service.

(3) Research on antenna for rear guard: This type of antenna was to be installed on the tail of the land based attack planes, and test preparations were under way.

SECTION 4 OF THE RADAR DEPARTMENT

Group 1:

(1) Research on shipborne radar detector (radar intercept): The shipborne radar detector is used aboard fighting surface crafts and submarines. The frequency band is divided into two groups; the centimeter group (3 centimeters to 75 centimeters), and the meter group (0.75 meters to 4 meters). Reception range extends well beyond the line-of-sight distance.

(2) Research on airborne radar detector: The airborne radar detector is intended for scouting aircraft and fighter planes. The wave length extends from 0.5 meters to 3.7 meters. Two sets of doublet antennas are installed on both sides of the craft. By means of automatic mechanical switching, the directional indications are had by the binaural principle or by the A-N system.

(3) Research on airborne night fighter radar (Gyoku-3): This radar is intended for twin-motored night fighter planes. The antenna, transmitter, and receiver are installed in the front nacelles. The antenna beam is electrically revolved by rotating the magnetic coupling coils. The polar indicator system is used, and is of "maximum" method. At altitude of 5000 meters, the maximum range is 4.5 kilometers against medium size aircrafts, and the minimum perceptible distance is 600 meters. The peak power output is 3 kilowatts.

(4) Short-wave direction finder: This direction finder is to be air transported and used at front line bases for signal intercept and homing aid. The Adcock antenna is 4 meters in length and of 4 meter span. The short wave receiver covers from 2.5 megacycles to 7 megacycles, and 4 megacycles to 10 megacycles.

Group 2:

(1) Research on IFF: The airborne IFF is intended for scouting craft and fighter planes. It is used in conjunction with airborne radars, and covers wave lengths from 1.5 meters to 6 meters. Coded signals are transmitted on all wave lengths within this band. Experimental determination of the accuracy and performance was not completed.

(2) Research on wireless beacons: The beacon is for aircraft and ship use. The wave lengths used are; 1,000 meters (50 kilowatts and 1 kilowatt), 100 meters (80 watts), and 50 meters (30 watts). A-N course indication is used, giving an accuracy better than 2°. The 50 meter beacon uses full visual indicator, but experiments had not been completed.

(3) Research on Lorentz system of blind landing: This is a copy of the German system. The wave length is 9 meters with power output of 500 watts.

Group 3:

(1) Theoretical study on impulse waves: The basic theory and design of impulse generators were studied. The immediate purpose was to develop the circuit for the night fighter radar Gyoku-3 which would improve its minimum perceptible range.

(2) Study of crystal detector: The purpose was to develop a suitable crystal detector to be used on centimeter wave radar intercepts. Uniform reception was desired from 3 centimeter to 75 centimeter wave band. Pyrite crystals with nickel contact feelers were developed. Experiments were being carried out on crystals of metallic silicon.

(3) Study of antennas: Thorough theoretical study of various forms of all wave, all around antenna led us to develop several practical designs. The "O" type antenna covers the 4 meter to 7.5 meter range. The "spherical" type antenna covers the 3 centimeter to 10 centimeter range.

Study was being made of the installation of the all wave 0.5 meter to 3.7 meter racket type antenna for airborne radar intercept. Also for the same use, the slit type rotating beam antenna was under investigation.

(4) Research on goniometer antenna coupler: The object was to ascertain the maximum gain of the goniometer antenna coupler used for night fighter radar, Gyoku-3.

(5) Research on revolving beam antenna for the airborne radar detector: The problem was to develop an antenna system using an all around "O" type antenna, and a doublet antenna with goniometer coupler to give revolving beam characteristics. Satisfactory antenna giving 2.7 db gain was developed.

(6) Research on full visual direction finder: The object was to develop a direction finder for a short interval signal reception, and for simultaneous multiple signal reception.

SECTION 5 OF THE RADAR DEPARTMENT

Group 1: Research on Electric Motors, Generators, and Motor Generators

Power sources for airborne radars and communication apparatuses and for elecrical instruments are highly exacting. Performances of motors greatly effect the overall efficiency of apparatuses. Therefore, detailed researches and tests were begun.

The following apparatuses were under test:

ENCLOSURE (B), continued

(1) 250 volt-ampere motor-generator for FK-3 radar: The rating of this machine is as follows; direct current input voltage of 13.5 volts, single phase alternating voltage of 110 volts, 400 cycles per second.

(2) Constant speed motor for radio altimeter: Specification required for this special motor is that the speed variation be less than 1% for changes in input voltage of 20, and under load torque variation of 50%. Also, remedy for wearing on brush contacts, springs, and commutator was under investigation.

(3) 1.5 kilovolt-ampere motor-generator for radar Type 51: This set is rated at direct current input of 27 volts, and generates 110 volts 3 phase, 400 cycles per second alternating current. The automatic voltage regulator for this set was under study.

(4) 25 watt generator for FP radar: This set is rated at direct current input voltage of 27 volts and output of 250 volts, 0.1 ampere direct current. Methods for eliminating noises produced in this machine were studied.

SECTION 1 OF THE COMMUNICATION DEPARTMENT

Group 1: Research on Frequency Standards

As primary standard of frequency, there were five frequency standards having variations of 5×10^{-8} cycles. These apparatuses were calibrated from the time signals from the astronomical observatory. With these apparatuses we monitored the standard frequency waves which were broadcast by the Communications Ministry. This work was started about twenty years ago and reached a high standard in Japan. However, the apparatuses were destroyed in April of this year by air raids.

Making use of these standards, simple and stable audio frequency generators, which consist of a crystal oscillator and a frequency dividing circuit were calibrated. We also investigated various mechanical vibrating systems, and lately developed a tuning bar which has a very high "Q" with very small temperature coefficient.

Group 2: Research on Multi-channel Communication

For multi-channel communication we adopted the time division system, which is very efficient due to the impulse communication principle. For inter-radar posts we had planned the three channel, phase modulated telephone at high frequencies.

Group 3: Research on Propagation of Electric Waves

Studying the data from the various communication stations on the critical frequency of ionized layers and the field intensities, we were able to select suitable frequencies for naval communications. Observations were carried out at the Hiratsuka Experiment Station, and the calculation and tabulating were done at the Tokyo Branch.

SECTION 3 OF THE COMMUNICATION DEPARTMENT

Group 1: Research on Wireless Telephones

(1) Wireless telephones for fighters (Type N-1): This apparatus has been in use for some time. The frequency band is from 5 megacycles to 10 megacycles with power output of around 25 watts.

ENCLOSURE (B), continued

(2) Research on the new wirless telephone for fighters (Type P-1): This apparatus is an improvement over the former in that two-wave selection by push button operation is had. Efforts also were made to improve the articulation. The apparatus is not in service as yet.

(3) Research on the ultra short wave wireless telephone (Type UP-3): Researches were directed towards improving the sensitivity of the receiver. Development had not been completed.

Group 2: Research on Airborne Wireless Telegraph Apparatuses

(1) Research on wireless telegraph apparatus for small and medium size planes (Type R-3): A compact apparatus adapted to mass production was developed. The frequency band is 2.5 megacycles to 10 megacycles with maximum power output of about 150 watts. The sets have been in service for several years.

(2) Research on wireless telegraph apparatus for large planes (Type R-4): The old design was to be revised in three respects: the circuit was to be standardized with that of Type R-3, the component parts were to be standardized to meet increased production schedule, and the electrical characteristics were to be improved. The apparatus has not been put in service.

(3) Research on wireless telegraph for airbase (Type AGS): A compact all-wave equipment suitable for air transportation was developed. The equipment was in production.

(4) Research on adapter for modulation: An adapter for changing wireless telegraph apparatus into telephone communication apparatus was developed. These are in mass production.

Group 3: Research on Transmitters:

(1) Research on new short-wave transmitter (Mark 5, Type 4): Prototype of this new standard design was being made. The power output is 500 watts, and transmits on frequencies from 2.5 megacycles to 10 megacycles.

(2) Research on improving wireless telephone transmitters: By redesigning the preamplifier, the operating characteristics were greatly improved. Also the carbon microphones were replaced by dynamic microphones. These apparatuses were in mass production.

(3) Research on adding telephone modulator to short-wave transmitter (Mark 5): The problem was to add a telephone modulator to the short-wave transmitter, Mark 5. A prototype was completed.

(4) Research on improving the frequency stability of transmitters: Experiments were under way to improve the frequency stability of transmitters.

Group 4: Research on Receiver Apparatuses

(1) Research on measurement instruments for receiver adjustments: A convenient measurement instrument to facilitate the adjustment of superhetrodyne receiver was developed. This instrument is used in adjusting the coils, the variable condensers, and the unicontrol mechanism. Prototype was completed.

ENCLOSURE (B), continued

(2) Redesign of ultra-long-wave receiver: The receiver for ultra-long-wave reception was being redesigned to facilitate increased production.

(3) Research on improving the coils: The object was to design a more efficient and convenient coil to replace the plug-in-coil for the all-wave receiver, Mark 92. The new design had not been turned over for production.

(4) Research on under water receiver antenna: Efforts were made to design a small compact under water antenna suited to mass production. The problem was solved by using dust cores.

A special type "Q" meter and several other instruments were also developed to facilitate manufacture of these antenna.

(5) Research on extending the wave range of the small type wireless telegraph apparatus: Research was initiated to extend the wave length of the small type short wave telegraph apparatus into medium wave band.

SECTION 4 OF THE COMMUNICATION DEPARTMENT

Group 1: Research on Wired Communications

(1) Model 1 small type carrier telephone terminal apparatus: This is a small type carrier telephone using bare line which carries five channels in the frequency between 60 kilocycles and 140 kilocycles. The net loss is about 25 db. The sets are in mass production.

(2) Model 3 telegraph terminal apparatus: This is a carrier telegraph with carrier frequency set at 1615 cycles, and is used in parallel with voice telephone circuit. The net loss is about 25 db. The instruments are in mass production.

(3) Model 5 carrier telephone terminal apparatus: This is an improved type of the Model 1 mentioned above, and has six channels in the frequency range between 36 kilocycles and 148 kilocycles. The net loss is between 25 db and 35 db. Although several prototypes were constructed in our laboratory, they were destroyed by air raids.

SECTION 5 OF THE COMMUNICATION DEPARTMENT

Group 1: Research on Radio Controlled Apparatuses

The research on the fundamental problems of radio controlled apparatuses for naval ships were being carried out in the special laboratory, using small-scale test models. Unfortunately, the air raid of April 16 burned completely all equipments and test models, and researches and experiments were suspended.

PRODUCTION SECTION OF THE RADAR DEPARTMENT

Outline:

The production section is in charge of the production of all radar and communication prototypes. Therefore, this section maintains close contact with numerous manufacturers.

As the office of this section was burned through the action of enemy air forces, all records and papers were destroyed. Several manufacturers suffered

ENCLOSURE (B), continued

similar losses.

The following apparatuses were being produced at the beginning of August, 1945:

Names of Apparatus	Manufacturer
Radar Type 22-C	Nitchiku, Anritsu, and Hitachi
Receivers for Radar Type 22-C	Nippon Musen
Radar Detector Type 3-A	Nanao Musen
Radar Detector Type 3-B	Sumitomo Tsushin, Nanao Musen, Anritsu
Indicators for Radar Detector Type 5	Nanao Musen
Radiation pattern measuring instrument	Oki
Direction finder (All wave)	Nippon Musen
Portable direction finder Type 97	Anritsu Musen
Direction finder Type 3	Fuji Tsushin
Direction finder (Medium wave)	Nippon Musen

PLANNING SECTION OF THE RADAR DEPARTMENT

Outline:

The planning section is composed of two groups, the planning group and the design group. Heads of other sections are members of the first groups, where research and experiments are mapped. The second group designs all apparatuses necessary in the experiment laboratories. However, in many instances detailed designing is not necessary, for experimenters may obtain equipments directly from manufacturers.

There are about 6000 sheets and 30 instruction books in the library of the design department.

INSPECTION SECTION OF THE RADAR DEPARTMENT

Outline:

The duty of this section is to inspect all radar and communication apparatuses which are in production under the management of the production section. This section is also authorized to change design to meet production processes. Work was mostly carried out at the manufacturing plants.

There are two offices, one at the Tokyo Branch and the other at the Kanazawa Headquarters. The Tokyo office is in charge of shipborne and land based equipments, while the Kanazawa office works with airborne equipments.

After passing inspections, the airborne apparatuses are delivered to the Munitions Bureau, while the shipborne and land based equipments are delivered to the production section of our department.

Since, as a rule, we do not keep such apparatuses in stock, there are only the following apparatuses on hand: Aircraft Wireless Telegraph Apparatus Model 96-3, Model 96-4, Model 19-3, Model 98-4; Aircraft Radar Model 3-6; Frequency meter Model 99-1; Ultra high frequency meter Model 96, and Model 96-1 and Radar frequency meter Model 1.

FIRST MACHINE SHOP OF THE RADAR DEPARTMENT

Outline:

The principal work of this shop is to make various kinds of apparatuses

ENCLOSURE (B), continued

necessary for experiments in our laboratories. Some simple radar and communication equipments are manufactured in the shop under orders from the Aeronautical Headquarters of the Japanese Navy.

The underground shop:

The underground shop was working on the following:

(1) Simplified vacuum tube tester
(2) Additional telephone modulator
(3) Reconstructing radar Model H-6 for 24 volt source
(4) Auxiliary indicators for radar Model H-6
(5) Molds for battery electrode

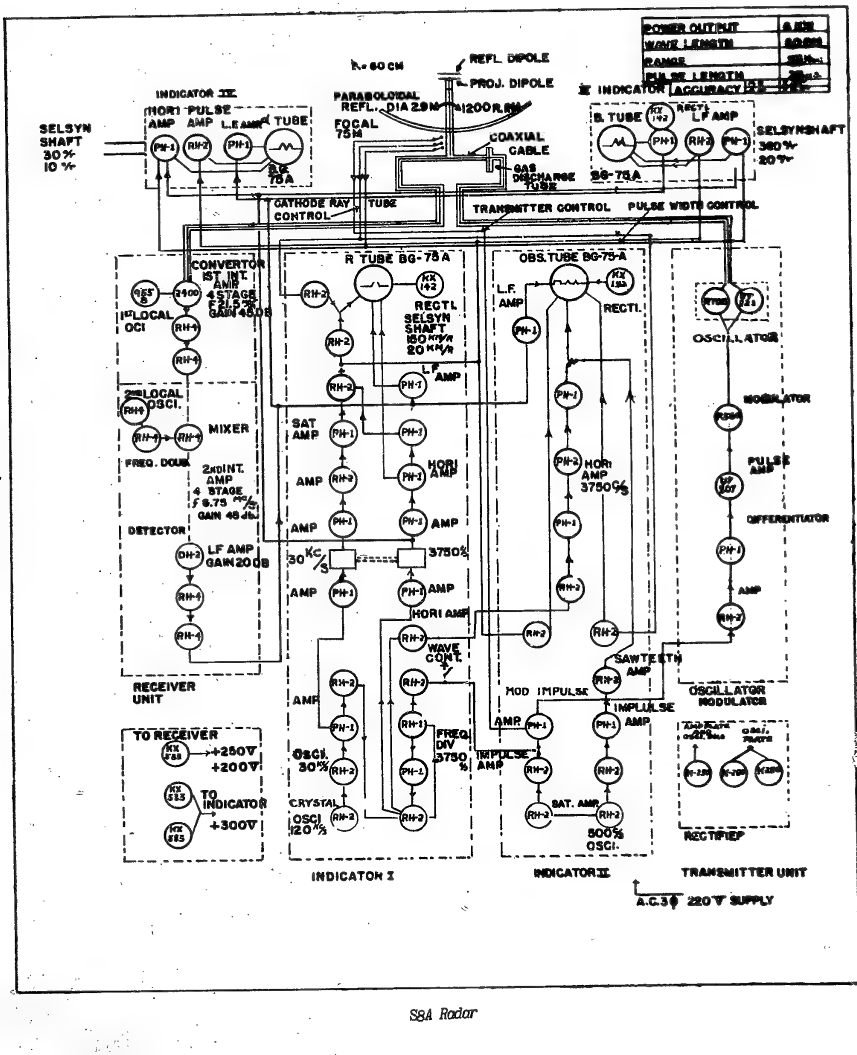
THE SECOND MACHINE SHOP OF THE RADAR DEPARTMENT

Outline:

As in the first machine shop, some instruments and apparatuses for experiments at the Tokyo Branch laboratories are made in this shop. However, it is inadequately equipped to construct equipments in any quantity.

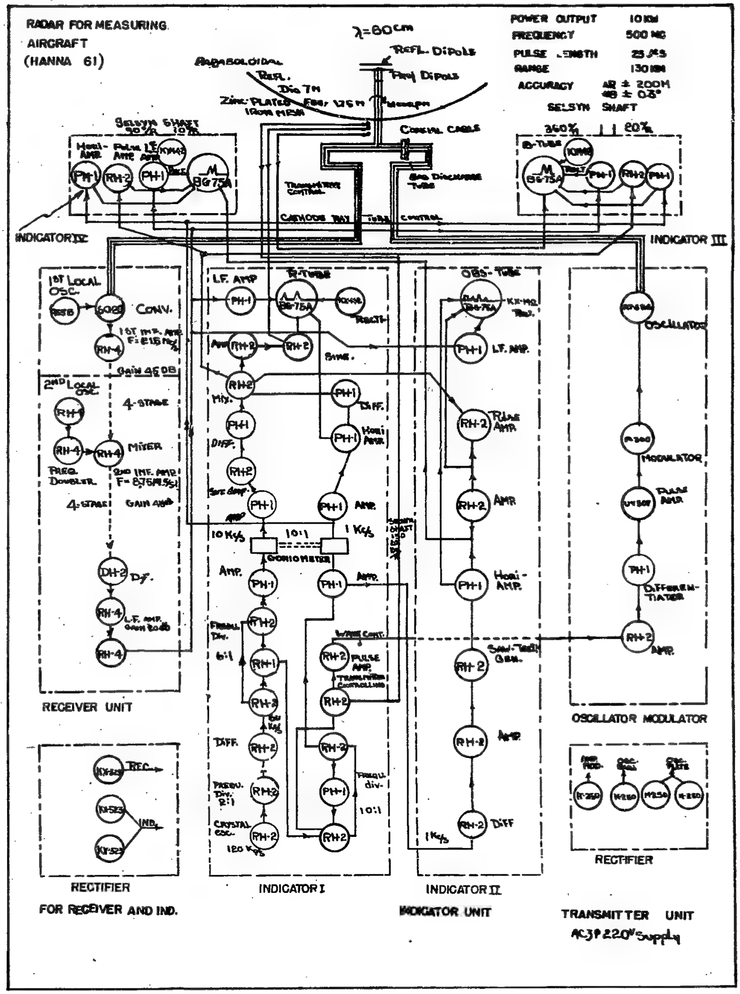
The recent action of the American bombers caused us to look for a suitable place to keep equipments out of danger.

ENCLOSURE (C)



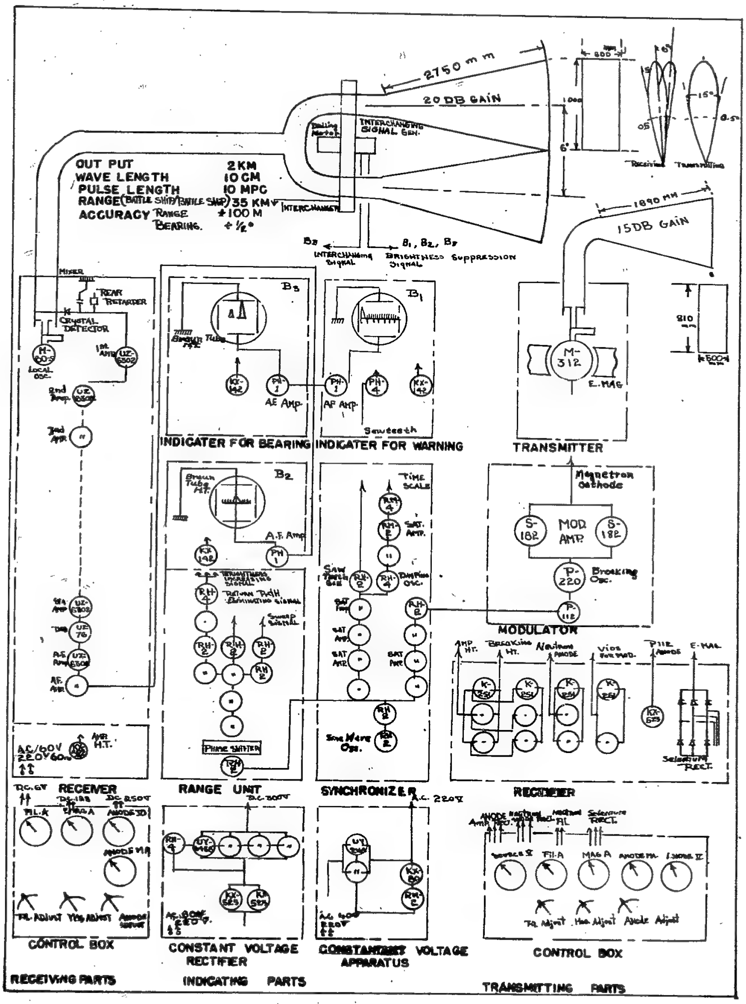
S8A Radar

ENCLOSURE (D)



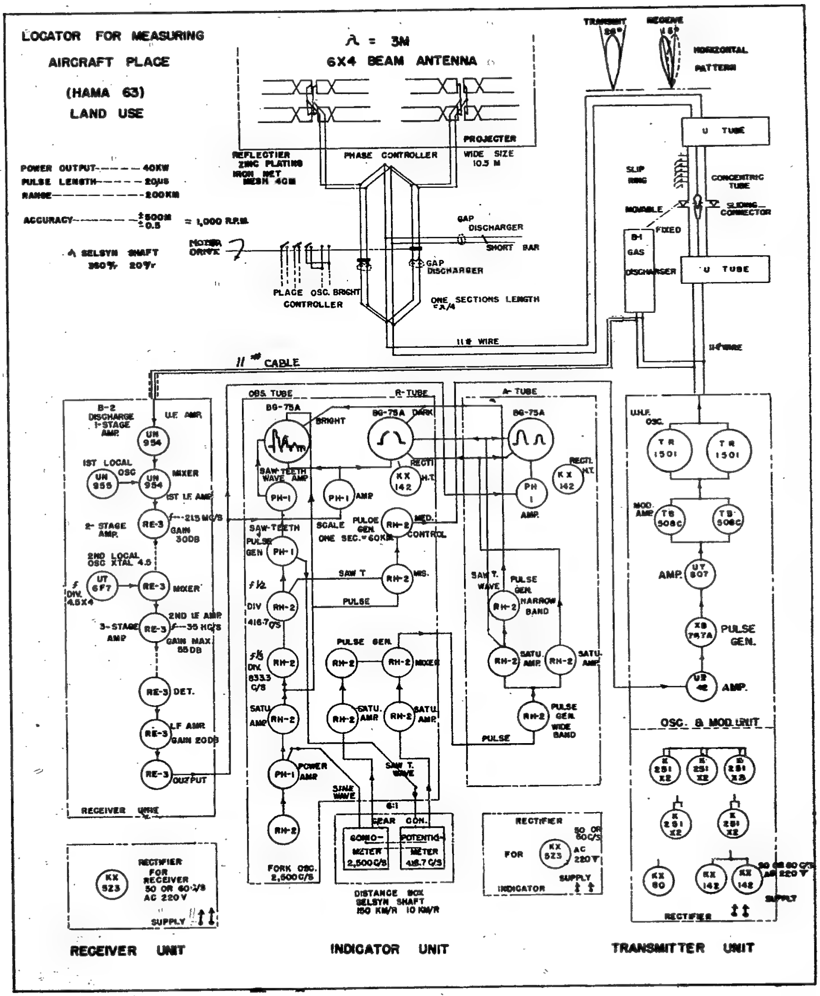
Mark 6, Model 1 - S8B

ENCLOSURE (E)



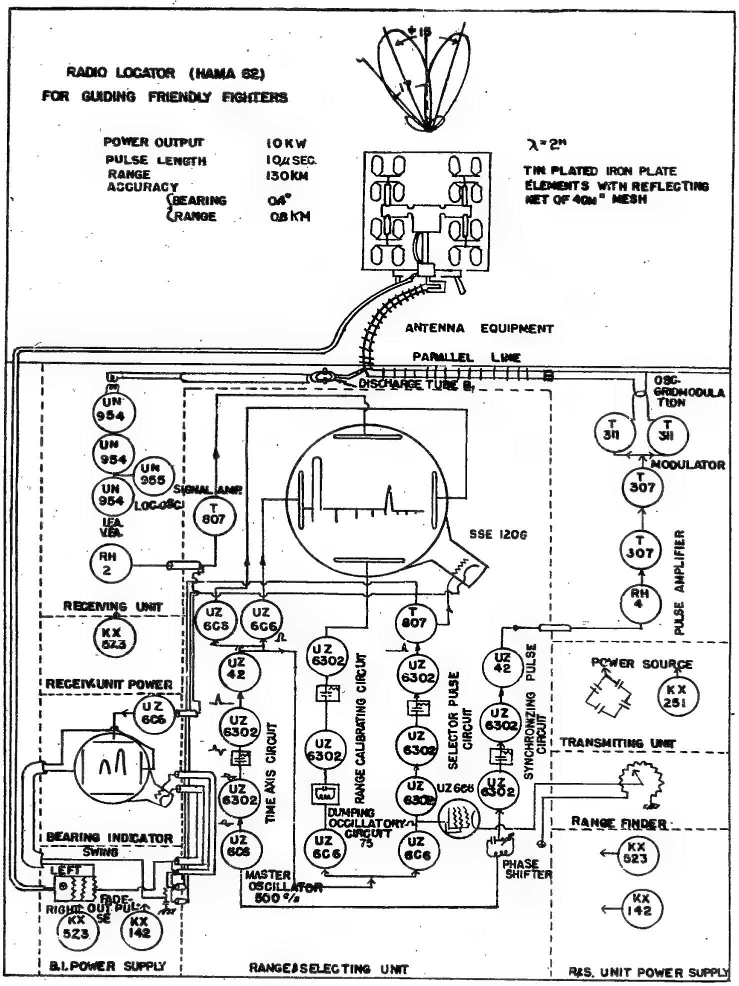
Mark 3, Model 2

ENCLOSURE (F)



Mark 6, Model 3

ENCLOSURE (G)



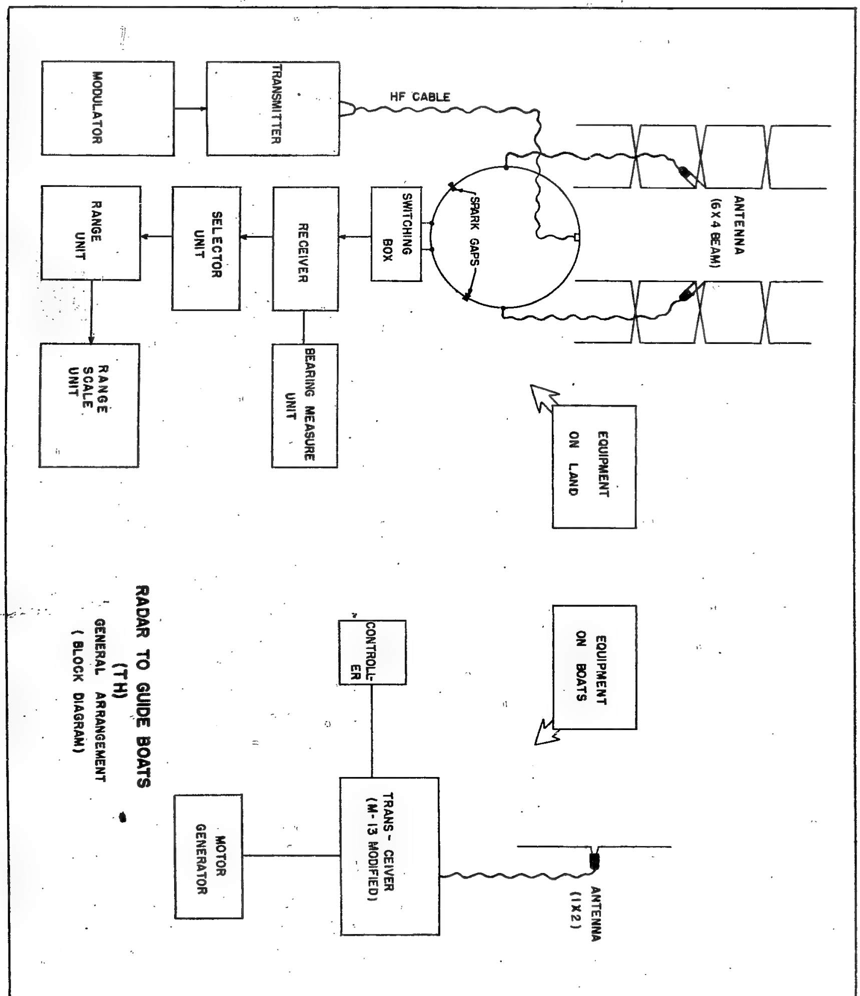
Mark 6, Model 2

ENCLOSURE (H)

TH RADAR

INDEX

ENCLOSURE (H), continued



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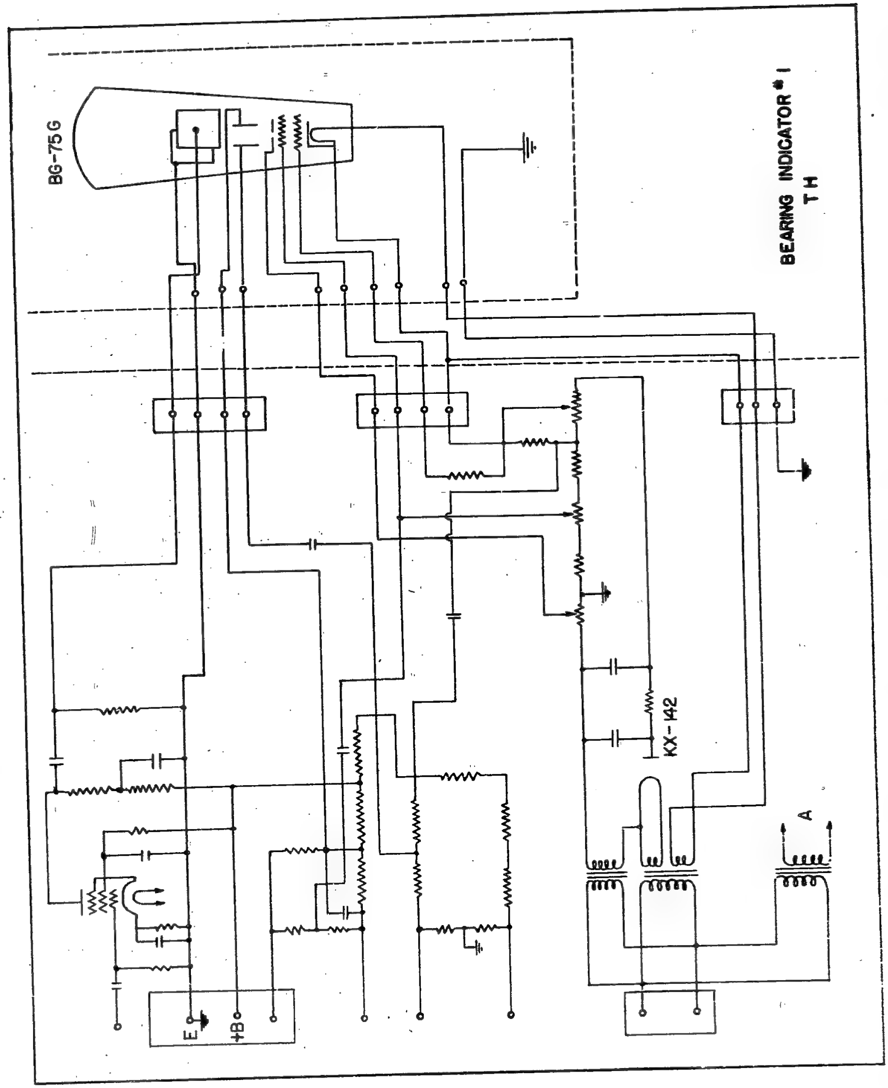

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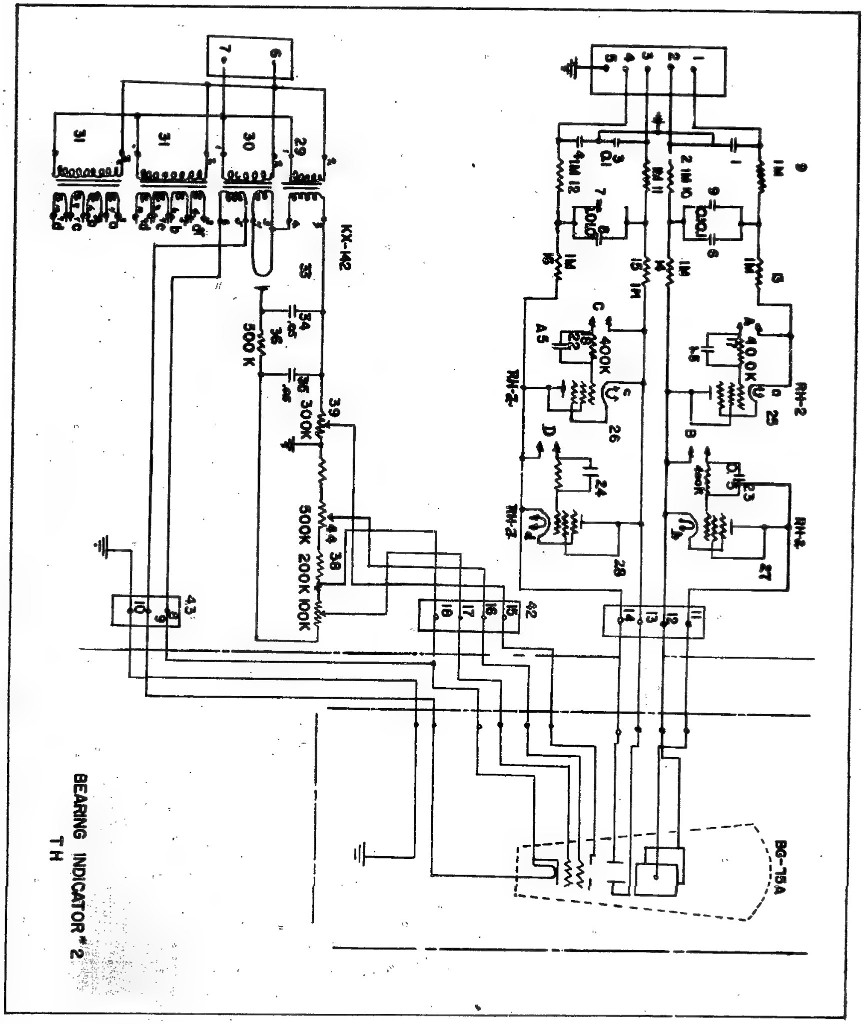

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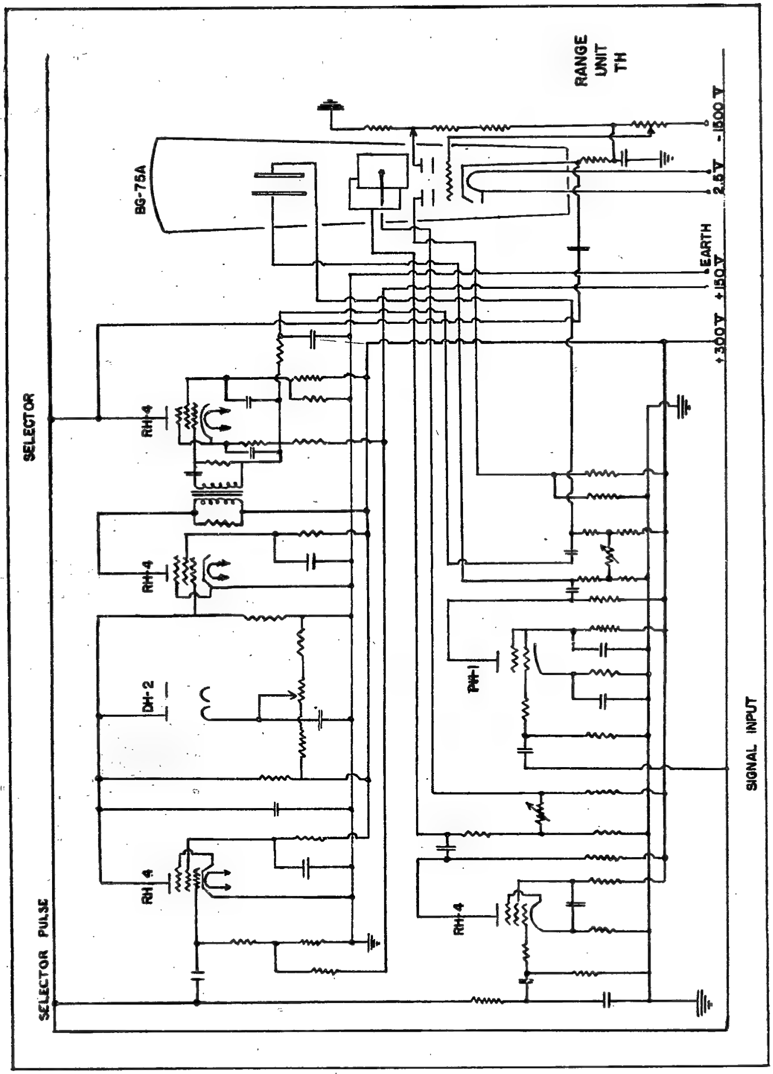

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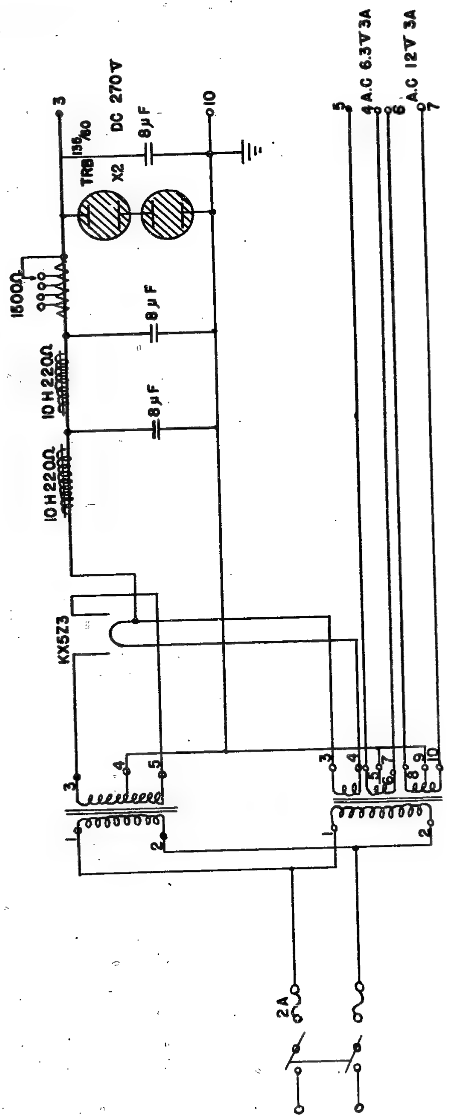
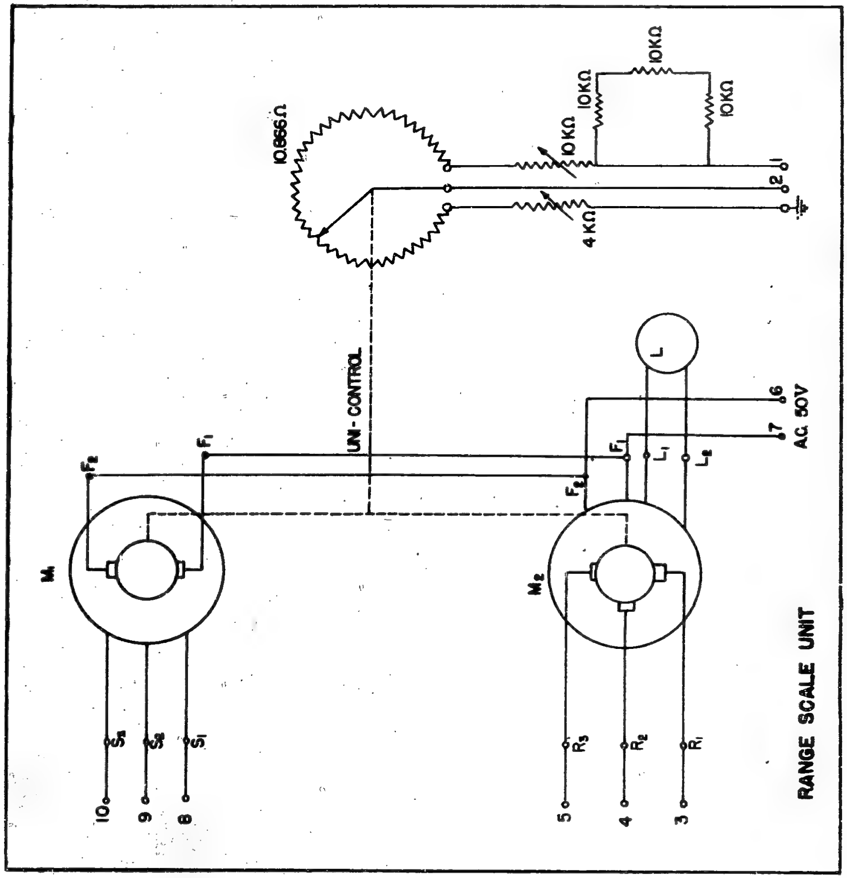


RECEIVER POWER SUPPLY

ENCLOSURE (H), continued



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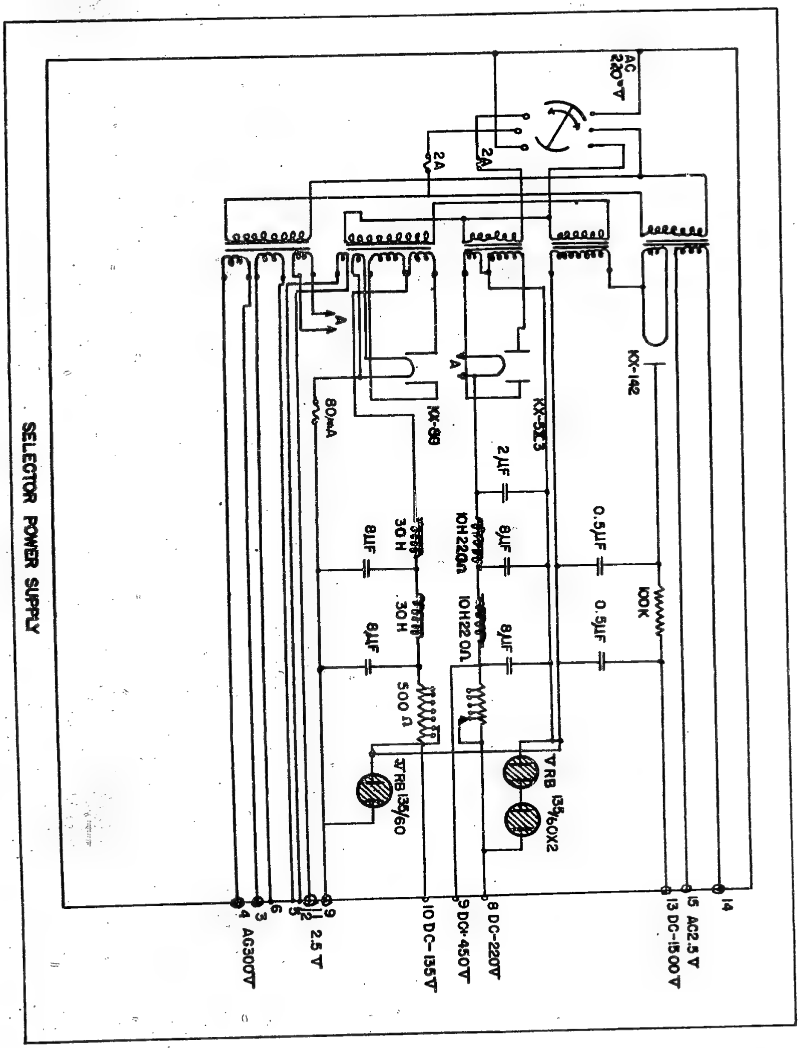

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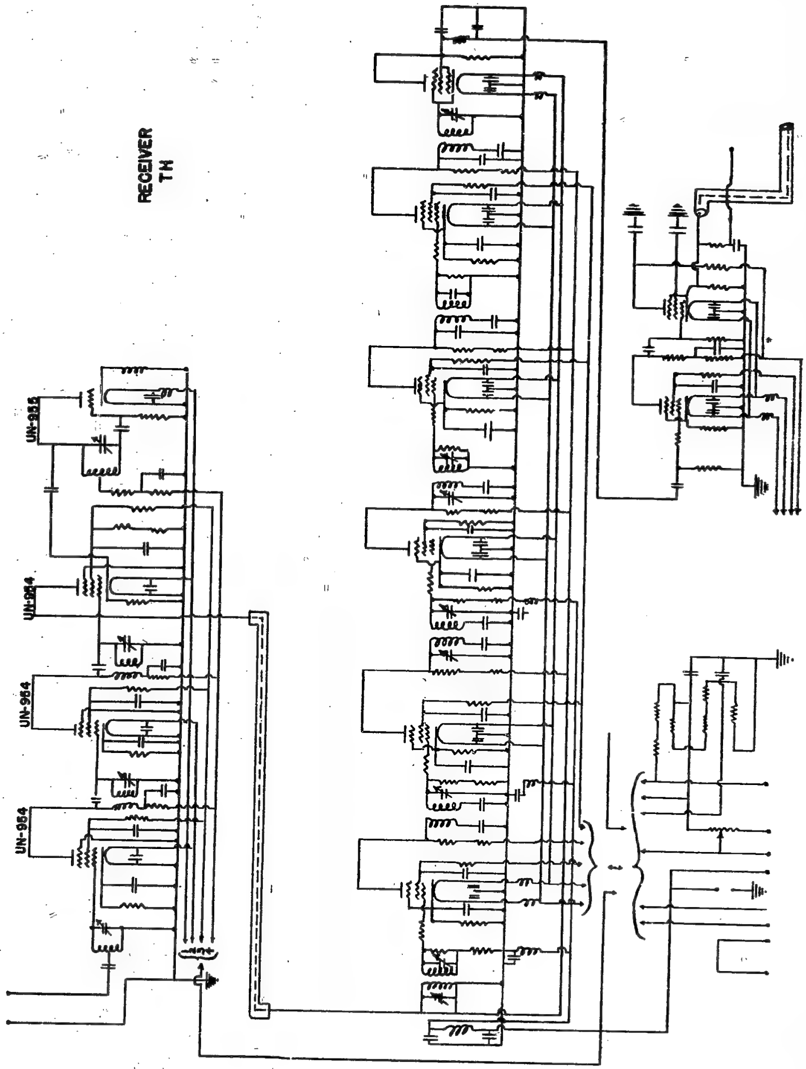

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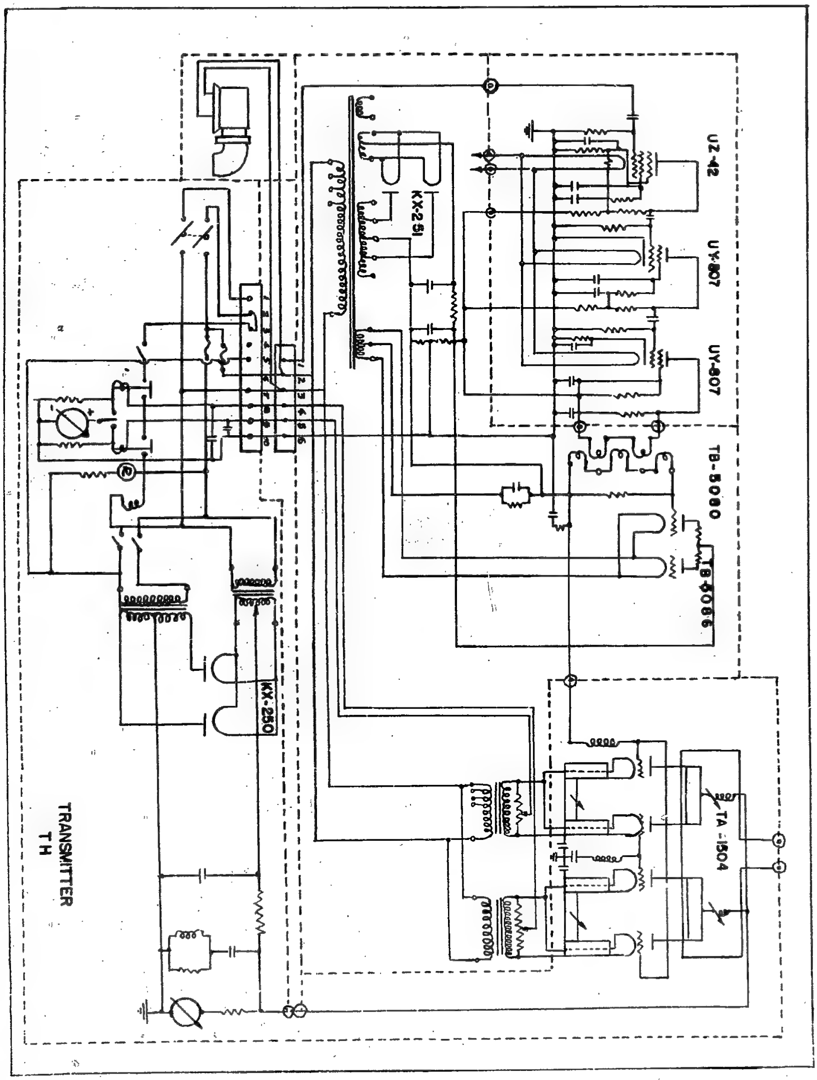

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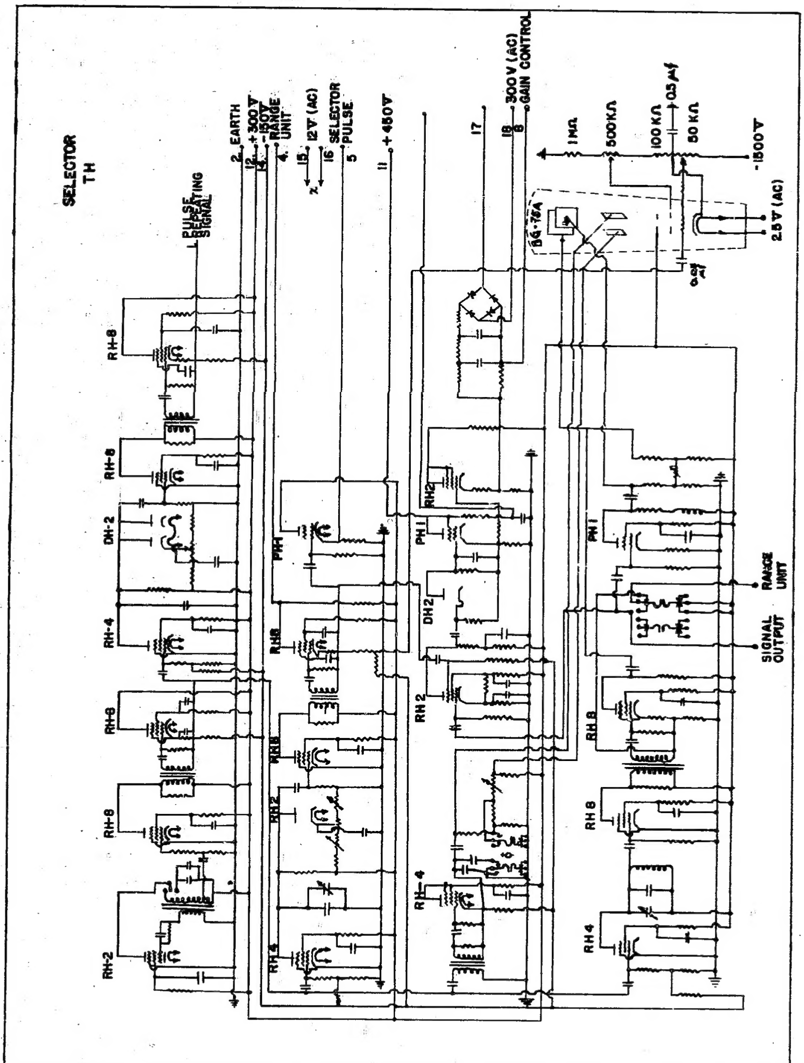

ENCLOSURE (I)

Summary of Japanese Radar

A. LAND BASED RADARS.

No.	Name	Designation	Object	Research Started	Research Finished	Remarks	Installations	Frequency Wave length	Power Output (peak) (KW)	Pulse Length (μs)	Repetition Frequency (c/s)	Oscillation Circuit	Oscillator Valve	Receiver: Intermediate Frequency	Receiver: Detector	Receiver: Local Oscillator
1	Mark-1 Model-4	14	Long range anti-air warning	1945-1	1945-5	in use	Important points	50MC (6m)	100	20	250	Back-coupled Oscillation(Parallel Wire)	TR-594A x 2	8.5MC	UN-954	UN-955
2	Mark-3	RD	Anti-air warning	1941-11	1942-10	installed but not used	Important points Inland	5m	500W	Continuous		Crystal Controlled Oscillator and Ampl.	P-220 x 2	3.5MC 200KC	UN-954	UN-955
3	Type-2 Mark-1 Model-1	11	Anti-air warning	1941-4	1942-3	out of use	Sea Shore	100MC(3m)	5	20	1,000	Resonator-tanc	TR-593A x 2	21.5MC 3.5MC	UN-954	UN-955
4	Type-2 Mark-1 Model-1-1	11-1	Anti-air warning	1941-11	1942-5	out of use	Sea Shore	100MC(3m)	5	20	1,000	LC-Circuit	TR-593A x 2	21.5MC 3.5MC	UN-954	UN-955
5	Type-2 Mark-1 Model-1-2	11-2	Anti-air warning	1942-5	1943-5	in use	Sea Shore	100MC(3m)	40	20	500	LC-Circuit	TR-1501 x 2	21.5MC 3.5MC	UN-954	UN-955
6	Type-2 Mark-1 Model-1-3	11-3	Anti-air warning	1943-5	1943-7	in use	Sea Shore	100MC(3m)	40	20	500	LC-Circuit	TR-1501 x 2	21.5MC 3.5MC	UN-954	UN-955
7	Prototype Air warning Radar	11-3-Kai	Anti-air warning	1945-1	1945-5	not yet used	Sea Shore	100MC(3m)	40	20	500	LC-Circuit	TR-1501 x 2	21.5MC 3.5MC	UN-954	UN-955
8	Type-3 Mark-1 Model-3 Land Based	13	Small size Anti-air warning	1943-4	1943-8	in use	Sea Shore	150MC(2m)	10	10	500	LC-Circuit	T-311 x 2	14.5MC	UN-954	UN-955
9	Type-3 Mark-1 Model-1	11-k	Medium size Anti-air warning	1943-5	1943-10	in use	Sea Shore	150MC(2m)	10	20	500	LC-Circuit	T-311 x 2	21.5MC 3.5MC	UN-954	UN-955
10	Type-2 Mark-1 Model-2	12	Portable Anti-air warning	1942-4	1942-12	in use	Sea Shore	200MC(1.5m)	5	10	1,000	LC-Circuit	T-310 x 2	21.5MC 3.5MC	UN-954	UN-955
11	Type-2 Mark-1 Model-2-2	12-Kai-2	Portable Anti-air warning	1943-8	1943-12	in use	Sea Shore	150MC(2m)	5	10	1,000	LC-Circuit	T-310 x 2	21.5MC 3.5MC	UN-954	UN-955
12	Type-2 Mark-1 Model-2-3	12-Kai-3	Portable Anti-air warning	1943-12	1944-4	in use	Sea Shore	150MC(2m)	5	10	500	LC-Circuit	T-310 x 2	21.5MC 3.5MC	UN-954	UN-955
13	Prototype Mark-4 Model-3	L_1	Searchlight control	1943-1	1943-4	out of use	Battery	1.5m	7	4	1,000	LC-Circuit	T-311 x 2	14.5MC	UN-954	UN-955
14	Prototype Mark-4 Model-3-1	L_2	Searchlight control	1943-1	1944-4	in use	Battery	1,5m	10	3	1,000	LC-Circuit	TA-1504 x 2	15MC	UN-954	UN-955
15	Prototype Mark-4 Model-3-2	L_3	Searchlight control	1944-4	1945-7	in use	Battery	1.5m	13	3	1,000	LC-Circuit	TA-1504 x 4	15MC	UN-954	UN-955
16	Prototype Mark-4 Model-1	S_3	Anti-aircraft fire control	1942-8	1943-8	in use	Battery	1.5m	13	3	1,000	LC-Circuit	TA-1504 x 4	15MC	UN-954	UN-955
17	Prototype Mark-4 Model-2	S_{2A}	Anti-aircraft fire control	1943-1	1944-10	in use	Battery	1.5m	13	3	1,000	LC-Circuit	TA-1504 x 4	14.5MC	UN-954	UN-955
18	Prototype Radar for A.A. Control	S_{8A}	Anti-aircraft fire control	1944-9	1944-12	not yet used	Battery	58cm	6	2.5	3,750	Shielded type Push-pull Oscillator	T-321 x 2	21.5MC 8.75MC	2400	UN-955B
19	Prototype Mark-6 Model-1	61(S_{8B})	Altitude measurement	1944-12	1945-4	in development	Airfields	60cm	10	2.5	1,875(No.1) 1,000	Shielded Type Single tube Oscillator	RT-326	21.5MC 8.75MC	2400	UN-955B
20	Prototype Mark-6 Model-2	62	Friendly aircraft locator	1945-1	1945-6	not yet used	Airfields	2m	10	10	500	Back-Coupled Oscillator (Parallel Wire)	T-311 x 2	14.5MC	UN-954 RH-2	UN-955
21	Prototype Mark-6 Model-3	63	Foe aircraft locator	1945-1		in development	Airfields	3m	40	20	416.7	LC-Circuit	T-311 x 2	21.5MC 3.5MC	UN-954	UN-955
22	Radar to guide boats	TH	To guide friendly boats	1944-12	1945-7	in development	Sea Shore	1.5m	13	6	1,000	LC-Circuit	TA-1504 x 4	15MC	UN-954	UN-955

No.	Scope Representation: Dia. (mm)	Scanning Axis	Scale	Antenna: Type	Gain (db)	Beam Angle: Horizontal	Beam Angle: Vertical	Max. Range: Max. Scale	Effective (km)	Min. Distance	Accuracy of Range	Distance Discrimination	Accuracy of Bearing	Angle Discrimination	Spare Parts	No. of Operators	Degree of Operating Difficulty	
1	120	Semi linear	Electric	Multiple Yagi-Ant Horizontal	14	±15°	±15°	550 450			± 5km	≒5km	±3~4°	≒30°		3	None	Almost no trouble
2	75	Linear		Horizontal Doublet with Reflector	3	60°		200		0km						2	None	Ordinary
3	120	Linear	Electric	Tr: Ant: 5 x 2Hor. Rec.Ant: 5 x 2Hor.	12.5 12.5	±14°	±40°	150 150		5km	±1~2km	≒3km	±2~3°	≒30°		2	Slight	Trouble- Frequently broke down
4	120	Linear	Electric	Tr. Ant: 5 x 2Hor. Rec.Ant: 5 x 2Hor.	12.5 12.5	±14°	±40°	150 150		5km	±1~2km	≒3km	±2~3°	≒30°		2	None	
5	120	Linear	Electric	Tr. Ant: 2 x 4Hor. Rec.Ant: 3 x 4Hor.	12 14	±32° ±32°	±17°	300 200		5km	±1~2km	≒3km	±3~4°	≒40°		2	None	
6	75	Linear	Optical	Tr. Ant: 2 x 4 Hor. Rec.Ant: 3 x 4Hor.	12 14	±32° ±22°	±17°	300 200		5km	±1~2km	≒3km	±3~4°	≒40°		2	None	Ordinary (at first trouble. Freq. broke down)
7	75	Warning: Linear Range Bearing: Sinusoidal		Common for Tr. and Rec. 6 x 4 Hor.	16.5	±11°	±17°	300 200		5km	±1~2km	≒3km	±1°	≒20°		3	None	
8	75	Linear	Mechanical	Common for Tr. and Rec. 2 x 4 Hor.	12	±32°	±17°	150 100		5km	±2~3km	≒3km	± 10°	≒60°		2	None	
9	75	Linear	Optical	Common for Tr. and Rec. 4 x 5 Hor.	16	±17°	±14°	300 150		5km	±2~3km	≒3km	± 5°	≒30°	Number of Vacuum Tubes in use x 3	2	None	
10	120	Linear	Electric	Tr. Ant: 2 x 4 Hor. Rec.Ant: 6 x 2 Hor.	14 14	±11°	±40°	150 100		5km	±1~2km	≒2km	± 5°	≒20°		2	None	Ordinary(Trouble in parts. Frequently broke down.)
11	120	Linear	Electric	Common for Tr. and Rec. 5 x 3 Hor.	14.5	±14°	±35°	150 100		5km	±1~2km	≒2km	± 7°	≒30°	Number of Resistances in use x 3	2	None	
12	75	Linear	Mechanical	Tr. Ant: 2 x 4 Hor. Rec.Ant: 2 x 4 Hor.	12	±32°	±17°	300 150		5km	±2~3km	≒2km	± 10°	≒60°		2	None	
13	Selection Range measurement: 120 and Indicator: 75 Logarithmic			Yagi Tr. Ant: Single Rec. Ant: 1-2-1 Hor.	5 8	A=50° B=20°	A=50° B=20°	150	10(20)	1500m	200m	1000m	± 3°	≒40°	Number of Condensers in use x 3	2	None	
14	75	Logarithmic	Electric	Multiple Yagi Hor. Tr: 1 x 2 Rec: 2 x 4	5 15	A=28° B=12° c/d<30%	A=26° B=12° c/d<30%	70	15(30)	1000m	150m	500m	±1.5°	≒30°		3	None	
15	75	Logarithmic	Electric	Multiple Yagi Hor. Tr: 1 x 2 Rec: 2 x 4	8 15	ditto	ditto	150	20(40)	600m	100m	500m	±1.5°	≒30°		3	None	
16	Selection Range measurement: 120 and Indicator: 75 Logarithmic			Tr. Ant: 4 x 4 Rec. Ant: 4 x 4 2 x 6 Hor.	15 15,14	ditto	ditto	150	20(40)	1500m	100m	1000m	± 1°	≒20°		4	None	Trouble with parts
17	75	Logarithmic	Electric	Multiple Yagi Tr. and Rec: 2 x 4 Hor.	18	A=32° B=11° c/d<30%	A=30° B=11° c/d<30%	150	20(50)	600m	50m	500m	±0.4°	≒20°		4	None	
18	75	Warning Linear Range Bearing: Sinusoidal		Paraboloid 2.9m Dia. Rotating	19	±10°	±10°	33	≒25(-)	600m	50m	Research Incomplete	±0.3°	Research Incompleted		4	None	
19	75	Warning: Linear Range Bearing: Sinusoidal		Paraboloid 7m Dia. Rotating	26	±4°	±4°	130	≒50(120)	600m	200m	Research Incomplete	±0.3°	Research Incompleted		4	None	
20	Selection:120 75	Logarithmic	Electric	4 x 4 Vertical	Equi echo System 15	±17°	±17°	150 130		2km	±0.8km		±0.4°			4	First Adjustment Difficult	Many troubles at first Broke down
21	75	Linear	Electric	Common for Tr. and Rec: 6 x 4 Hor.	16.5	±17°	±17°	300 200		Research Incomplete	Estimated 500m	Research Incomplete	Research Incomplete	Research Incompleted		3	Research Incompleted	Not yet Tested
22				Common for Tr. and Rec: 6 x 4 Vert.	16.5	±11°	±17°	40 20		1000m	500m	1000m	±0.5°	≒20°		4	Ordinary	Ordinary

B. SHIPBORNE RADARS.

No.	Name	Designation	Object	Research Started	Research Finished	Remarks	Installation	Freq. Wave	Pulse Length μs	Power Output (Peak) kw	Rep. Freq. cs	Transmitter: Oscillation Circuit	Transmitter: Oscillator Value	Receiver: Inter. Freq. (mc)	Receiver: Detector	Receiver: Local Oscillator
1	Type-3 Mark-1 Model-3 for ships	13 for ship	Anti-air warning	1943-9	1944-2	in use	Both sides of Mizzen Mast	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
2		13 for Submarine Anti-Air	Anti-air warning	1943-9	1944-5	in use	Communication Mast	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
3		13 for Submarine Anti-Air	Anti-air warning	1943-9	1944-7	in use	On Conning Tower	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
4		13 for small vessels	Anti-air warning	1943-9	1944-7	in use	Foremast	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
5	Type-2 Mark-2 Model-1	21	Anti-air warning	1942-1	1942-4	in use	Bridge (Converted Merchant Ship)	1.5m	10	5	1000	LC-Circuit	T-310x2	21.5 3.5	UN-954	UN-955
6		21-Kai-1	Anti-air warning	1942-8	1942-12	out of use	Fore-top	11.5m	10	5	1000	LC-Circuit	T-310x2	21.5 3.5	UN-954	UN-955
7		21-Kai-2	Anti-air warning	1943-5	1943-8	in use	Fore-top	1.5m	10	5	1000	LC-Circuit	T-310x2	21.5 3.5	UN-954	UN-955
8		21-Kai-3	Anti-air and Anti-surface warning	1943-8	1944-2	out of use	Fore-top	1.5m	6-10	30	500	LC-Circuit	T-311x4	21.5 3.5	UN-954	UN-955
9		21-Kai-4	Anti-air and Anti-surface warning	1944-2	1944-5	research stopped	Fore-top	1.5m	10	30	1000	LC-Circuit	T-311x4	21.5 3.5	UN-954	UN-959
10		21-Kai-5	Anti-air warning and surface fire control	1944-5	1944-9	not yet used	Fore-top	1.5m	6	30	1000	LC-Circuit	T-311x4	21.5 3.5	UN-954	UN-955
11		F8	Anti-surface warning	1943-3	1943-10	research stopped		58 cm	5	2	500	Resonator-tanc	SN-7 x2	21.5 8.75	2400	UN-955B
12	Type-3 Mark-2 Model-3	23(S_8)	Anti-surface fire control	1943-10	1944-3	not yet used	Fore-top	58 cm	2.5	5	3750	Resonator-tanc	T-321	21.5 8.75	2400	UN-955B
13	Prototype Mark-2 Model-4	24	Anti-surface fire control	1943-11	1945-4 stopped	reasearch stopped		28 cm	2	1	1000	Parallel wire (standing wave)	LD-212-Cx2	15	Crystal	LD-1
14	Prototype Mark-2 Model-2	22-Kai-1	Anti-surface warning	1941-10	1942-6	out of use	Fore-or Mizzen Mast	10 cm	10	500w	2500	Magnetron	M-311	Super regenerative	M-60	
15		22-Kai-2	Anti-surface warning	1942-6	1942-12	out of use	Fore-or Mizzen Mast	10 cm	10	2	2500	Magnetron	M-312	Autodyne	M-60-A	
16		22-Kai-3	Anti-surface warning	1942-10	1943-6	in use	Conning Tower of Submarine	10 cm	10	2	600	Magnetron	M-312-B	14±1	Crystal	M-60-S
17		22-Kai-4	Anti-surface warning	1942-12 1943-12	1943-12 1944-9	in use	Fore-or Mizzen Mast	10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S
18	Prototype Mark-3 Model-1	220	Anti-surface fire control	1944-2	1945-3	not yet used	Fore Mast and Sea Shore	10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S
19	Prototype Mark-3 Model-3	105 S_1	Anti-surface fire control	1944-5	1945-1 stopped	research stopped		10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S
20	Prototype Mark-3 Model-2	105 S_2	Anti-surface fire control	1944-2	1944-9	not yet used	Fore-Mast of Battle-ship or Sea Shore	10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S

No.	Scope Representation: Dia. in mm	Scanning axis	Scale	Antenna: Type	Gain (db)	Beam Hor.	Angle Vert.	Maximum Range, Scale Effective (km)	Minimum Distance (km)	Accuracy of Range	Distance Discrimination	Accuracy of Bearing	Angle Discrimination	Spare Parts	No. of Operators	Degree of Operating Difficulty	Maintenance
1	75	Linear	Mechanical	2 x 4 Horizontal	12	±34°	± 17.5°	150(300) 100	5	± 2~3km	3km	±10°	≒60°		2	None	Few troubles
2	75	Linear	Mechanical	Single Vertical	≃ 3	360°		150(300) 30	5	± 2~3km	3km				2	None	Antenna System gave trouble
3	75	Linear	Mechanical	Yagi Hor.	7	±30°	± 25°	150(300) 15	5	± 2~3km	3km	± 5°	≒60°	Number of Vacuum Tubes in use x 3	2	None	Antenna System gave trouble
4	75	Linear	Mechanical	2 x 4 Hor.	12	±34°	± 17.5°	150(300) 100	5	± 2~3km	3km	± 5°	≒60°		2	None	Antenna System gave trouble
5	120	Linear	Electric	6 x 2 6 x 2 Hor.	14 14	±11°	± 40°	150 100	5	± 1~2km	≃ 2km	± 5°	≒20°	Number of Resistances in use x 1/3	2	None	At first trouble Frequently broke down
6	120	Linear	Electric	4 x 2 3 x 2 Hor.	12 11	±17° ±23°	± 40°	150 70	5	± 1~2km	≒2km	± 8°	≒40°		2	Slight	Antenna System gave trouble
7	120	Linear	Electric	4 x 3 Hor.	14	±17°	± 30°	150 100	5	± 1~2km	≒2km	± 5°	≒20°	Number of Condensers in Use x 1/3	2	None	No troubles
8	75	Linear	Optical Electric	4 x 3 Hor.	14	±17°	± 30°	270, 14 against a battleship	4	± 0.5km	1km	± 1°	8°		4	Difficult	Liable to break down
9	120	Linear	Electric	4 x 4 Hor. Interchangeable	15	±17°	± 17.5°	150, 15 against a battleship	5	± 1.0km	1,5km	± 1°	8°		3	Difficult	Liable to break down
10	120	Linear	Electric	4 x 4 Hor. Interchangeable	15	±17°	± 17.5°	150, 20 against a battleship	4	± 0.5km	1km	± 1°	8°	—	3	Difficult	Ordinary
11	120	Curve	Mechanical	Tr: Paraboloid 1'7m dia. Rec. 1.7m Vertical	11	±25°	± 25°	150, 15 against a cruiser	1.3	± 2km	Research Incompleted	± 3°	Research Incompleted		1	None	Not yet tested
12	75	Warning: Linear Range and Bearing: Sinusoidal		Tr: Paraboloid 1.7m dia. Rec. 1.7m Rotating	11 11	±25°	± 25°	33, 22 against a battleship	1	± 50m	150km	±0.5°	14°		3	None	Liable to break down
13	75	Logarithmic	Electric	Tr: Paraboloid 2m dia. Rec. 2mDouble Ant.(switch)	19 19	± 9°	± 9°	40, 11 against a battleship	1	± 50m	150 m	±0.5°	14°		3	None	Gave some trouble
14	120	Linear	Electric	Paraboloid 0.8 x 1'7m	15	±15°	± 15°	60, 30 against a battleship	1.5	± 500m	1.5km	± 3°	≒±30°		3	Difficult	Gave some trouble
15	120	Linear	Electric	Horn 400mm	13	±19°	± 19°	60, 22 against a battleship	1.5	± 500m	1.5km	± 3°	≒±40°		3	Slight	Gave some trouble
16	75	Linear		Horn 400mm	13	±19°	± 19°	60, 10 against a battleship	1.5	± 500m	1.5km	± 3°	≒±40°	Number of Resistances in use x 1/10	3	None	No trouble
17	75	Linear	Electric	Horn 400mm	13	±19°	± 19°	60, 25 against a battleship	1.5	±100~250m	1.5km	± 3°	≒±40°	Number of Vacuum Tubes in use x 4	3	None	No trouble
18	75	Warning: Linear, Range and Bearing: Sinusoidal		Paraboloid	25	± 7°	± 7°	60, 35 against a battleship	1.5	±100~250m	1.5km	±40°	≒±15°	Number of Magnetron in use x 5	3~4	Slight	No trouble
19	75	Warning: Linear, Range and Bearing: Sinusoidal		Horn, Tr: 1 Rec: 2	15	±15°	± 15°	60, 28 against a battleship	1.5	±100~250m	1.5km	±30°	≒±30°		4	None	No trouble
20	75	Warning: Linear, Range and Bearing: Sinusoidal		Horn, Tr: 1 Rec: 2	20 15	±15° ±20°	± 18° ± 10°	60, 30 against a battleship	1.5	±100~250m	1.5km	±30°	≒±30°			None	No trouble

Summary of Japanese Radar (Continued)

No.	Name	Designation	Object	Research Started	Research Finished	Remark	Installation	Frequency Wave Length	Power Output (Peak)	Pulse Length	Repetition Frequency	Transmitter Oscillation Circuit	Transmitter Oscillator Valve	Receiver Intermed. Freq.	Receiver Detector	Receiver Local Oscil.
1	Type-3 Air Mark-6 Model-4 Radio	H-6	Patrol and search	11/41	8/42	In use	Large and Small Aircraft, Observer's Seat	2m	3kw	10μS	1000c/s	Blocking Oscillator	U-233 x2	10mc	1st UN-95A 2nd FM-2A05A	UN-955
2	Type-4 Air Mark-6 Model-3 Radio	FM-1	Patrol and search	2/44	9/44	Out of use	Small Aircraft, Observer's Seat	2m	4.2kw	15μS	250c/s	Modulated Oscillator	T-319 x2	10mc	1st UN-954 2nd SORA	UN-955
3	Prototype 19 Air Mark-1 Model-12 Radio	FK-3	Patrol and search	10/44	6/45	Not yet used	Small Aircraft, Observer's Seat	2m	2kw	10μS	1000c/s	Blocking Oscillator	U-233 x2	10mc	1st UN-954 2nd FM-2A05A	UN-955
4	Warning Radar for Large Aircraft	FK-4	Patrol and search	6/44	7/49 Stopped	Research stopped		2m	20kw	20μS	83c/s(500 c/s x 1/6)	Modulated Oscillator	K-3006 x2	10mc	1st UN-954 2nd SORA	UN-955
5	Prototype 19 Air Mark-1 Model-11 Radar	N-6	Patrol and search	3/43	10/44 Stopped	Not yet used	Small Aircraft, Observer's Seat	1.2m	2kw	5μS	1000c/s	Modulated Oscillator	T-319 x2	10mc	1st UN-954 2nd FM-2A05A	UN-955
6	Prototype 18 Air Mark-6 Model-2 Radio	FD-1	Patrol and search	12/43	2/44 Stopped	Not yet used		60cm	2.5kw	3μS	1000c/s	Modulated Oscillator	T-321 x1	10mc	1st 2400 2nd FM-2A05A	UN-955
7	Prototype 18 Air Mark-6 Model Radio	FD-2	Night fighter	4/44	8/44	Not yet used	Transmitter--Head, Indicator Observer's Seat	62m	2.5kw	3μS	1000c/s	Modulated Oscillator	T-321 x1	10mc	1st 2400 2nd FM-2A05A	UN-955
8	Prototype 19 Air Mark-2 Model-11 Radar	Gyoku-3	Night fighter	9/44	7/45	Not yet used		2m	3kw	2μS	2500c/s	Modulated Oscillator	T-319 x2	17.75mc	1st UN-954 2nd SORA	UN-955
9	Prototype 5 Model-1 IFF	M-13	IFF (Friend aircraft locating)	10/44	7/45	Not yet used	Bottom	2m	50w	0.6μS		Modulated by Thyratron	T-304		UN-955	
10	Prototype Model-1 Height Measuring Radar	FH-1	Height measure		2/45	In use	In the Wings	340mc±15mc	0.1w	Continuous		Self Oscillator	T-304-A		UN-955	
11	Prototype 19 Air Mark-3 Model-30 Radar	51	Path finder	9/44		On test		10cm	6kw	14μS	600c/s	Magnetron	M-314	14mc	1st Crystal 2nd	UN-955
12	Prototype 2 Air Mark-7 Model-2 Radio	FT-B	Radar counter measure	1/43	5/44	Not yet used	Large Aircraft, Observer's Seat	3.7m~0.45m						25mc	1st UN-955x2 2nd FM-2A05A	UN-955
13	Prototype 2 Air Mark-7 Model-3 Radio	FTC	Radar counter measure				Large Aircraft, Observer's Seat	3.7m~0.45m						0~1mc	1st UN-955x2 2nd SORA	UN-955

No.	Scope Representation Dia. (mm)	Scanning Axis	Scale	Type	Gain	Beam Angle Horiz.	Beam Angle Vertical	Max. Range (Max. Effective Scale)	Minimum Distance	Accuracy of Range	Distance Discrimination	Accuracy of Bearing	Angle Discrimination	Spare Parts	No. of Operators	Degree of Operating Difficulty	Maintenance	No.
1	120	Linear	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_f = 30^\circ$ $\theta_f = 35^\circ$	$\theta_f = 28^\circ$ $\theta_f = 30^\circ$	150 (110 against a large Ship)	3km(H=1000m)	≃±5%	2~3 km	±3°	≃60°		Radar Technician by large Plane. Observer by small	None	Ordinary	1
2	120	Sinusoidal	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_f = 30^\circ$ $\theta_f = 35^\circ$	$\theta_f = 28^\circ$ $\theta_f = 30^\circ$	250 (110 against a large Ship)	5 km(H=1000m)	≃±5%	4 km	±3°	≃60°		Observer	None	Ordinary	2
3	75	Linear, Logarithmic	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_f = 30^\circ$ $\theta_f = 35^\circ$	$\theta_f = 28^\circ$ $\theta_f = 30^\circ$	150 (60 against a large Ship)	3 km(H=1000m)	≃±5%	4~5 km	±3°	≃60°		Observer	None	Ordinary	3
4	120	Linear	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_f = 30^\circ$ $\theta_f = 35^\circ$	$\theta_f = 28^\circ$ $\theta_f = 30^\circ$	300 (150 against a large Ship)	5 km(H=1000m)	≃±5%	5 km	±3°	≃60°		Radar Technician	None		4
5	75	Logarithmic	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_f = 30^\circ$ $\theta_f = 35^\circ$	$\theta_f = 28^\circ$ $\theta_f = 30^\circ$	150 (40 against a large Ship)	2.5 km(H=1000m)	≃±5%	1.5~2 km	±3°	≃60°	Number of Vacuum Tubes in Use x3	Observer	None	Ordinary	5
6	75	Sinusoidal	None	Yagi Antenna	8db	≃30°	≃30°	75 (20 against a large Ship)	600m	≃±5%	≃500 m	±0.5°	≃60°	Number of Resistances in Use x1	Observer	None	Ordinary	6
7	75	Sinusoidal	None	Yagi Antenna	8db	≃30°	≃30°	75 (3 against a large Ship)	600m	≃±5%	≃500 m	±0.5°	≃60°	Number of Condensers in Use x1	Pilot	None	Ordinary	7
8	75	Circular and Linear		Combination of Ant. and Doublet with Goniometer	2.5~3db	±70°	±70°	10 (4.5 against a large Ship)	400~600m	≃±5%	≃500 m	±5°	≃100°	Number of Fuses in Use x3	Pilot	None	Ordinary	8
9		(Earpiece)		L-Shaped Antenna	Nondirectional			110		About ±0.8km with radar 62				Number of Transformers in use x1	Pilot	Slight	Ordinary	9
10		D.C. Ammeter		Doublet	0db			0~200m (10m~150m)		≃±5%					Pilot Observer	None	Gave some trouble	10
11	120	Circular		Doublet with Parabolic Mirror	18db	±7°	±12°	100 (20)	≃1500m	Research Incomplete	Research Incomplete	Research Incomplete	Research Incomplete		Radar Technician	Slight	Ordinary	11
12		(Earpiece)		Racket Ant. and θ Ant.	-5~15db	±50°		Over 250				±5°	2~6°		Radar Technician	None		12
13		(Earpiece and Meter)		Racket Ant. and θ Ant.	-5~15db	±50°		Over 250				±5°	2~6°		Radar Technician			13

Land-Based and Shipborne Radar Counter Measures

No.	Name	Designation	Object	Research Started	Research Finished	Remarks	Installation	Frequency Band (Wave length)	Receiver Type	Receiver Local Oscillator	Receiver Intermediate Frequency	Receiver Tubes	Receiver Gain
1	Radar Counter Measure Kai 3	E 27	RCM for meter-wave	6/43	4/44	In use	Surface Ships and Submarines	7.5mc~400mc (40m~0.75m)	Single Tuning Superheterodyne	Parallel Wire Single Tuning	14.5mc	Un-955x3 UZ-6C6x9	119db
2	Radar Counter Measure Model-3		RCM for cm-wave	1/44	4/44	In use	Surface and Submarine (Land)	400mc~10,000mc (0.75m~0.03m)	Crystal Detecto		17.5 ± 3.5mc	UZ-6C6x4 UZ-42x1	119db
3	Racket-antenna		RCM for meter-wave	6/43	12/44	In use	Surface and Submarine	4m~0.75m		Receiver Used, Kai-3 (E-27)			
4	Metox-antenna		RCM for meter-wave	6/43	12/44	In use	Surface and Submarine	4m~0.75m		Receiver Used, Kai-3 (E-27)			
5	θ - antenna		RCM for meter-wave	6/44	12/44	Not yet used	Surface and Submarine	4m~0.75m		Receiver Used, Kai-3 (E-27)			
6	Mark-49 Antenna		RCM for cm-wave	6/44	12/44	In use	Surface and Submarine, Land	0.80m~0.03m		Receiver Used, Model-3			
7	Spherical Antenna		RCM for cm-wave	3/45	7/45	Not yet used	Surface and Submarine, Land	0.15m~0.03m		Receiver Used, Model-3			

No.	Type of Indication	Antenna Type	Antenna Kind	Antenna Gain	Beam Angle Horizontal	Beam Angle Vertical		Spare Parts	No. of Operators	Degree of Operating Difficulty	Maintenance	No.
1	Aural Visual: For Directional and Repetition Frequency	Directional: Racket-antenna (Rotating Fixed for Surface craft) All-around: Metox-antenna or θ - antenna						Number of Vacuum Tubes in Use x3 Few Replacement Parts	One	None	No trouble	1
2	Aural Visual: For Directional and Repetition Frequency	Directional: Parabolic Disc Type (Mark-49) (Portable) All-around: Spherical-antenna						Number of Vacuum Tubes in Use x3	One	None	No trouble	2
3		Rotating, Fixed	Directional	-3db	30°~50°	30°~50°				None	Liable to Insulation Breakdown	3
4		Fixed	All-around	-6db						None	Liable to Insulation Breakdown	4
5		Fixed	All-around	-6db						None	No trouble	5
6		Portable	Directional	+5db	10°~40°	10°~40°				Slightly Difficult aboard Subs	No trouble	6
7		Fixed	All-around	-20db						None	No trouble	7